REMARKS

This response is being submitted within four months of Office Action outstanding, dated December 17, 2002. Enclosed is a Request for a One Month Time Extension to extend the time for response to April 17, 2003. Applicants request the fee for the One Month Time Extension be withdrawn from Applicants' Deposit Account No. 19-1457.

By this Response, claims 1 and 21 have been amended. Claims 1-2, 4-12 and 21-22 are pending in the application. Claims 1, 9 and 21 are in independent form. No claim fees are required for this amendment.

In the Office Action dated December 17, 2002, the Examiner rejects claims 1, 2, 4-6, 8-11 and 21-22 under 35 USC 102(e) as being anticipated by Itoh et al. (US. Pat. No. 6,455,421, hereinafter "Itoh"). Applicants respectfully disagree.

Itoh teaches a plasma process to reduce the resistivity of a barrier layer. In particular, Itoh teaches subjecting a Tantalum Nitride (TaN) layer to a reactive plasma:

> "The showerhead 120 and the wafer support pedestal 150 also form a pair of spaced apart electrodes. When an electric field is generated between these electrodes, the process gases introduced into the chamber 100 are ignited into a plasma. Typically, the electric field is generated by connecting the wafer support pedestal 150 to a source of radio frequency (RF) power (not shown) through a matching network (not shown). Alternatively, the RF power source and matching network may be coupled to the showerhead 120, or coupled to both the showerhead 120 and the wafer support pedestal 150.
>
> Plasma enhanced chemical vapor deposition (PECVD) techniques promote excitation and/or dissociation of the reactant gases by the application of the electric field to the reaction zone near th substrate surface, creating a plasma of reactiv species. The reactivity of the species in the plasma reduces the nergy required for a chemical reaction to take place, in ffect lowering the

required temperature for such PECVD processes." (Itoh, column 3, lines 7-25, emphasis added).

As clearly taught by Itoh a "gas" is not the same thing as a "plasma". Moreover, use of a mere "gas" in the process of Itoh would not accomplish the goal of Itoh, i.e., use of a gas would not accomplish the high energy plasma chemical reaction that "reduce[s] the resistivity" of Itoh's TaN layer. (Itoh, column 6, line 4).

In contrast, Applicants' claimed process is not a high energy plasma chemical reaction but instead is a process of subjecting a barrier metal layer to a gas. Applicants will address each of independent claims 1, 9 and 21 in turn.

Applicants' claim 1 recites "subjecting said barrier metal layer to an atmosphere chosen from the group consisting of: an ambient vacuum, hydrogen gas, argon gas and helium gas" (emphasis added). Applicants use the term "consisting of" which eliminates the addition of a plasma to the recited atmospheres. Applicants also recite a list of non-plasma atmospheres: "ambient vacuum, hydrogen gas, argon gas and helium gas." Moreover, Applicants' use of a gas such as "ambient vacuum, hydrogen gas, argon gas and helium gas" teaches away from Itoh's use of a high energy plasma. Accordingly, Applicants believe claim 1 is not taught or suggested by Itoh and Applicants respectfully request allowance of the same. Nevertheless, to further emphasize Applicants' use of a mere gas and not a plasma, Applicants have amended claim 1 to recite "subjecting said barrier metal layer to a non-plasma atmosphere chosen from the group consisting of: an ambi nt vacuum, hydrog n gas, argon gas and h lium gas" (emphasis added). Applicants believ claim 1 as amended is not taught or

suggested by Itoh and Applicants respectfully request allowance of claim 1 and corresponding dependent claims 2, 4-6 and 8.

Applicants' claim 9 recites "subjecting said barrier metal layer to . . . an atmosphere chosen from the group consisting of: an ambient vacuum, Hydrogen gas, Argon gas, and Helium gas." As recited above with respect to claim 1, Applicants use "consisting of" language in claim 9. Moreover, Applicants recite a non-plasma atmosphere, namely, "ambient vacuum, Hydrogen gas, Argon gas, and Helium gas." Itoh does not teach or suggest a process the utilizes an atmosphere "consisting of: an ambient vacuum, Hydrogen gas, Argon gas, and Helium gas." Accordingly, Applicants believe claim 9 is not taught or suggest by Itoh and Applicants respectfully request allowance of claim 9 and corresponding dependent claims 10 and 11.

Applicants' claim 21 as amended recites "subjecting said barrier metal layer to a temperature greater than 200 degrees Celsius, while said barrier metal layer is subjected to a non-reactive atmosphere." (emphasis added). Itoh does not teach or suggest subjecting a barrier metal layer to "a non-reactive atmosphere." As stated above, Itoh's process utilizes "a plasma of reactive species" that is "ignited into a plasma" by an electric field generated between electrodes. (Itoh, column 3, lines 7-25). Accordingly, Applicants believe claim 21 as amended is not taught or suggest by Itoh and Applicants respectfully request allowance of claim 21 and corresponding dependent claim 22.

In the Office Action dated December 17, 2002, the Examiner rejects claims 7 and 12 under 35 USC 103(a) as being unpatentable under Itoh and further in view of Paranjpe et al. (US. Pat. No. 6,461,675, hereinafter "Paranjpe"). Paranjpe

fails to supplement the shortcomings of Itoh. Claims 7 and 12 are dependent on independent claims 1 and 9, respectively, discussed above. For the above listed reasons, Applicants believe claims 7 and 12 are in condition for allowance and Applicants respectfully request the same.

Conclusion

In view of the above noted amendments and remarks this application is believed to be in condition for allowance and notice thereof is respectfully solicited. The Examiner is urged to contact Applicants' attorney at the number listed below if there are any questions.

Applicants respectfully request entry of this Amendment and consideration of the application as amended.

Respectfully submitted,

Date: 4/17/03

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Appendix A

The following page 8 of the present Response indicate the changes to the claims made herein in application Serial Number 09/820,068, filed March 28, 2001

Deleted material is indicated in brackets [ ] and added material is underlined.

1. (Twice Amended) A method of pre-treating a barrier metal layer of a partially finished integrated circuit device prior to the deposition of a copper film thereon, comprising the steps of:

providing a partially finished integrated circuit device including a barrier metal layer;

subjecting said barrier metal layer to [an] a non-plasma atmosphere chosen from the group consisting of: an ambient vacuum, hydrogen gas, argon gas and helium gas;

subjecting said barrier metal layer to a temperature greater than 200 degrees Celsius for at least thirty seconds to form a pre-treated barrier metal layer; and

depositing a copper film on said pre-treated barrier metal layer.

21. (First Amended) A method of pre-treating a barrier metal layer of a partially finished integrated circuit device prior to the deposition of a copper film thereon, comprising the steps of:

providing a partially finished integrated circuit device including a barrier metal layer;

subjecting said barrier metal layer to a temperature greater than 200 degrees Celsius [and to], while said barrier metal layer is subjected to a non-reactive atmosphere, for at least thirty seconds to form a pre-treated barrier metal layer; and

depositing a copper film on said pre-treated barrier metal layer.

Appendix B

The following pages 10-13 of the present Response indicate the full, clean set of claims currently pending in application Serial Number 09/820,068, filed March 28, 2001

Sub D7

1. (Twice Amended) A method of pre-treating a barrier metal layer of a partially finished integrated circuit device prior to the deposition of a copper film thereon, comprising the steps of:

providing a partially finished integrated circuit device including a barrier metal layer;

C1

subjecting said barrier metal layer to a non-plasma atmosphere chosen from the group consisting of an ambient vacuum, hydrogen gas, argon gas and helium gas;

subjecting said barrier metal layer to a temperature greater than 200 degrees Celsius for at least thirty seconds to form a pre-treated barrier metal layer; and

depositing a copper film on said pre-treated barrier metal layer.

2. The method of claim 1 wherein said step of subjecting said barrier metal layer to a temperature comprises subjecting the barrier metal layer to a temperature in a range of 250 to 550 degrees Celsius.

3. Cancelled.

4. The method of claim 1, prior to depositing said copper film on said pre-treated barrier metal layer, further comprising the step of subjecting said barrier metal layer to a pressure in a range of 0.1 mTorr to 20 Torr.

5. The method of claim 1, wherein said barrier metal layer is subjected to a temperature greater than 200 degrees for 30 to 100 seconds.

6. The method of claim 1 wherein said barrier metal layer comprises a trench having a side wall, a bottom surface, and a width of 0.13µm or less, and wherein said copper film is deposited by chemical vapor deposition throughout said trench and against said side wall and said bottom surface.

7. The method of claim 1 wherein said copper film deposited on said pre-treated barrier metal layer has adhesion properties such that said copper film remains adhered to said pre-treated barrier metal layer when said copper film is subjected to a tape test.

8. The method of claim 1 wherein said barrier metal layer is chosen from the group consisting of TiN and TaN.

9. (First Amended) A method of pre-treating a barrier metal layer of a partially finished integrated circuit device for the deposition of a copper film thereon, comprising the steps of:

providing a partially finished integrated circuit device including a barrier metal layer having a trench therein;

C2

subjecting said barrier metal layer to a temperature greater than 200 degrees Celsius for at least thirty seconds in an atmosph re chosen from the

group consisting of: an ambient vacuum, Hydrogen gas, Argon gas, and Helium gas to form a pre-treated barrier metal layer; and

C2 cont'd

thereafter depositing a copper film on said pre-treated barrier metal layer and throughout said trench,

wherein said barrier metal layer comprises TiN.

10. The method of claim 9, simultaneous to subjecting said barrier metal layer to said atmosphere, further comprising the step of subjecting said barrier metal layer to a pressure in a range of 0.1 mTorr to 20 Torr.

11. The method of claim 9 wherein said trench has a width of 0.13μm or less.

12. The method of claim 9 wherein said copper film deposited on said pre-treated barrier metal layer has adhesion properties such that said copper film remains adhered to said pre-treated barrier metal layer when said copper film is subjected to a tape test, and wherein said copper film has uniform properties there through.

13-20. Cancelled.

C3

21. (First Amended) A method of pre-treating a barrier metal layer of a partially finished integrated circuit device prior to the deposition of a copper film thereon, comprising the steps of:

providing a partially finished integrated circuit device including a barri r metal layer;

subjecting said barrier metal layer to a temperature greater than 200 degrees Celsius, while said barrier metal layer is subjected to a non-reactive atmosphere, for at least thirty seconds to form a pre-treated barrier metal layer; and

depositing a copper film on said pre-treated barrier metal layer.

C3 cont'd

22. The method of claim 21 wherein said non-reactive atmosphere is chosen from the group consisting essentially of: an ambient vacuum, hydrogen gas, argon gas and helium gas.